INVESTIGATION OF SEVERAL ASPECTS OF LANDSAT-4 DATA QUALITY

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QUARTERLY PROGRESS REPORT

DECEMBER 20, 1983

The Thematic Mapper scene of San Francisco, CA (44/34) acquired during the TDRSS test was received in scrounge format in November. Preliminary analysis of band-to-band registration in this scene by flickering different band pairs on the display showed no major problems. It was difficult to tell whether or not the misregistration between the cooled and uncooled focal planes had been corrected completely or if the themal band was still misregistered. Unfortunately, the computer we used to extract blocks for correlation analysis was retired November 1 and its replacement does not yet have the necessary programs installed. Hence, we have been unable to perform the quantitative block correlation analysis on the August San Francisco scene.

We reported previously on Fourier analysis of a portion of the Washington, DC scene of November 2, 1982: for a 256x256 area of uniform water in Chesapeake Bay, several components of periodic noise were observed in TM bands 1-4. In the present reporting period, we calculated the power spectra of individual lines in each band on the A-tape which represented data from individual detectors. We averaged all the power spectra for each detector and calculated the peak-to-peak amplitudes as a function of frequency. For the 32 kHz component our results agree with measurements of peak-to-peak amplitude reported by John Barker during instrument calibration for bands 1 and 2. Thus, our post-launch results confirm Barker's pre-launch results and extend them to other bands and components.

The paper "Thematic Mapper Image Quality: Preliminary Results" by Wrigley et al. which had been presented at the IGARS '83 Symposium was reworked and expanded for submittal to the May issue of IEEE Transactions on Geoscience and Remote Sensing. The expansion incorporated both the periodic noise work reported here and in the previous progress report as well as the MTF work by Schowengerdt compairing forward-and back-scans and P-tape to A-tape data. The paper was accepted for publication and two copies are enclosed.

Schowengerdt began the system MTF measurements using the San Francisco scene of December 31, 1982. Tape copying problems at Ames prevented work on Bands 1, 5, 6 or 7 and Band 2 had very low contrast so he concentrated on Bands 3 and


They extracted a 128 x 128 pixel area of San Francisco Bay containing the San Mateo Bridge and calculated the power spectrum. After correction for the angle of the bridge with respect to the scan lines and for the finite width of the bridge (determined from engineering drawing of the bridge), they calculated estimated system MTF's for Bands 3 and 4. The estimated system MTF's were noisy and even-termed polynomials were fitted to each MTF as in the earlier work. The shape and width of the estimated MTF's appear reasonable, but further study is necessary to establish confidence in these first results. These results yield an effective-instantaneous-field-of-view of 33.6 meters and 40.8 meters in bands 3 and 4, respectively. A copy of Schowengerdt's progress report is appended to this report.

# LANDSAT-4 THEMATIC MAPPER MODULATION TRANSFER FUNCTION (MTF) EVALUATION

Progress Report

September 15, 1983 - December 15, 1983

submitted to

NASA Ames Research Center
Moffett Field, California

Robert Schowengerdt, Principal Investigator
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## INTRODUCTION

During this contract period we have begun analysis of the overall TM system MTF. The San Francisco scene of December 31, 1982 has been used in this analysis. Because of tape copy problems, bands 1, 5, 6 and 7 have not been analyzed during this period. A new set of tapes for this scene have just been received and will be used in the next contract quarter.

## PROCEDURE

The San Mateo Bridge across the southern end of San Francisco Bay provides a narrow, moderately high contrast, straight target for MTF analysis. A 128 x 128 pixel area containing the long span of the bridge and surrounding water was extracted from bands 3 and 4 (the contrast between the bridge and water in band 2 was too low to permit analysis). The starting sample and line coordinates relative to the full scene for this extracted area are 2953 and 2440, respectively.

The two-dimensional FFT and its squared modulus, or power spectrum (PS), was then calculated. The majority of energy in the PS is perpendicular to the bridge azimuth (an angle of 31.1° to the TM scan lines in the P-data). The profile of the PS in this direction, after correction for the non-zero width of the bridge, may be used to estimate the TM system MTF. An algorithm was written to extract PS values in the desired direction by linearly interpolating a value at the appropriate location within each line of the PS. The linear interpolation has the added benefit of smoothing some of the noise in the PS.

In order to correct the sampled PS for the width of the bridge, the spatial frequency interval in the profile must be calculated (Fig. 1). This interval is given by

$$\Delta v' = \Delta v/\cos(31.1^\circ)$$

$$= 1.17\Delta v$$

where $\Delta v$ is the equal spatial frequency interval in the $v_x$ and the $v_y$ directions of the PS and 31.1° is the angle of the bridge to the scan direction. The PS of the bridge itself is assumed to be that of a rectangle function of radiance that is 18.3m wide (determined from engineering drawings of the bridge). This corresponds to a sinc(Vv) function [sinc(x)=sin(πx)/πx] in the frequency domain, with the first zero at V = 1/18.3 cycles/m or 1.56 cycles/pixel for a 28.5m pixel.

The corrected PS is then calculated as

$$PS' = PS/|\mathrm{sinc}(1.56v)|^2$$

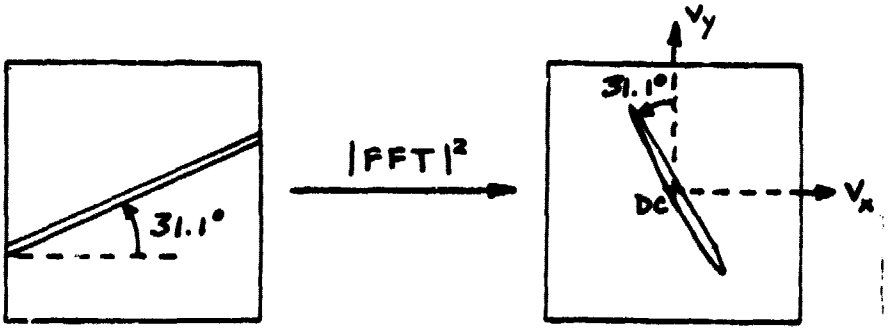
and the estimated system MTF is

$$MTF' = \sqrt{PS'}$$

As in our earlier work, residual noise in the MTF is smoothed by a polynomial function fitted to the raw data. Only even terms are allowed in the polynomial because the PS is an even function of frequency, i.e. PS(-v) = PS(+v). The resulting MTFs for bands 3 and 4 are shown in Figure 2. The shape and width of the estimated MTFs appear reasonable, but further study is necessary to establish confidence in these first results.

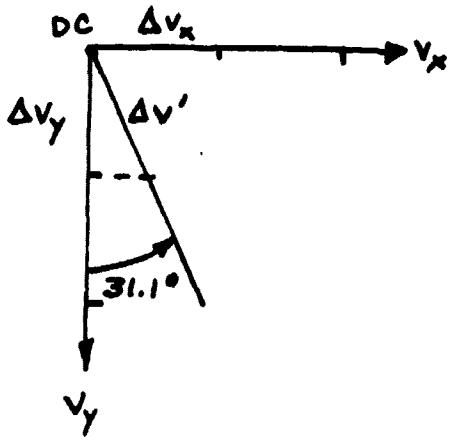
SUMMARY

The overall TM system MTF has been estimated from P-data using a simple high contrast target, the San Mateo Bridge over San Francisco Bay. The results yield an effective-instantaneous-field-of-view (EIFOV) of 33.6m and 40.8m in bands 3 and 4, respectively. Further analysis is necessary to substantiate these numbers, however. This work will continue on the 12/31/82 and 8/12/83 TM scenes during the next contract quarter. All underflight imagery has been received for the 8/12/83 scene and will be used to provide calibration of the TM scene.



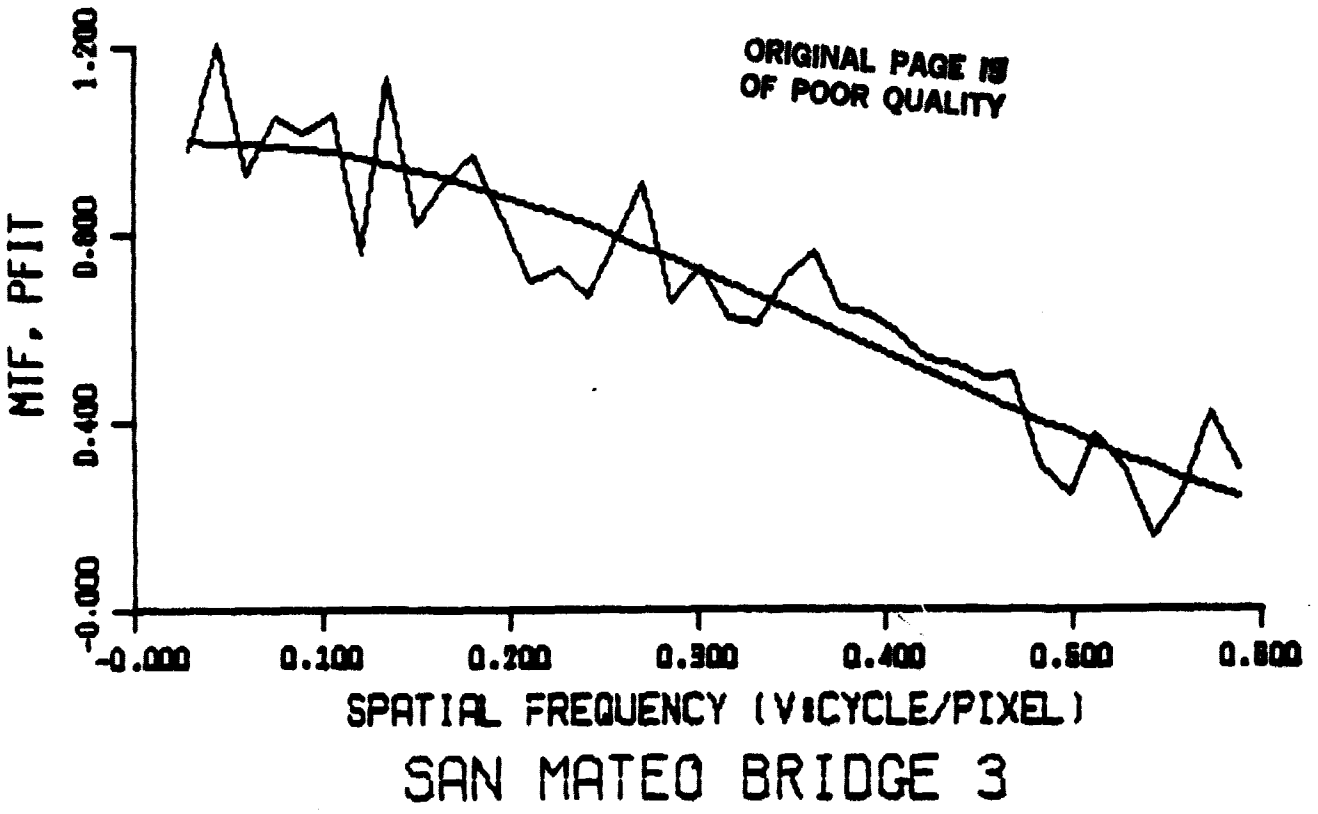

bridge power spectrum

(a) relationship between angles in the spatial and frequency domains




(b) calculation of the sample interval along an angle

Figure 1. Geometry of the San Mateo Bridge Analysis in the spatial and frequency domains



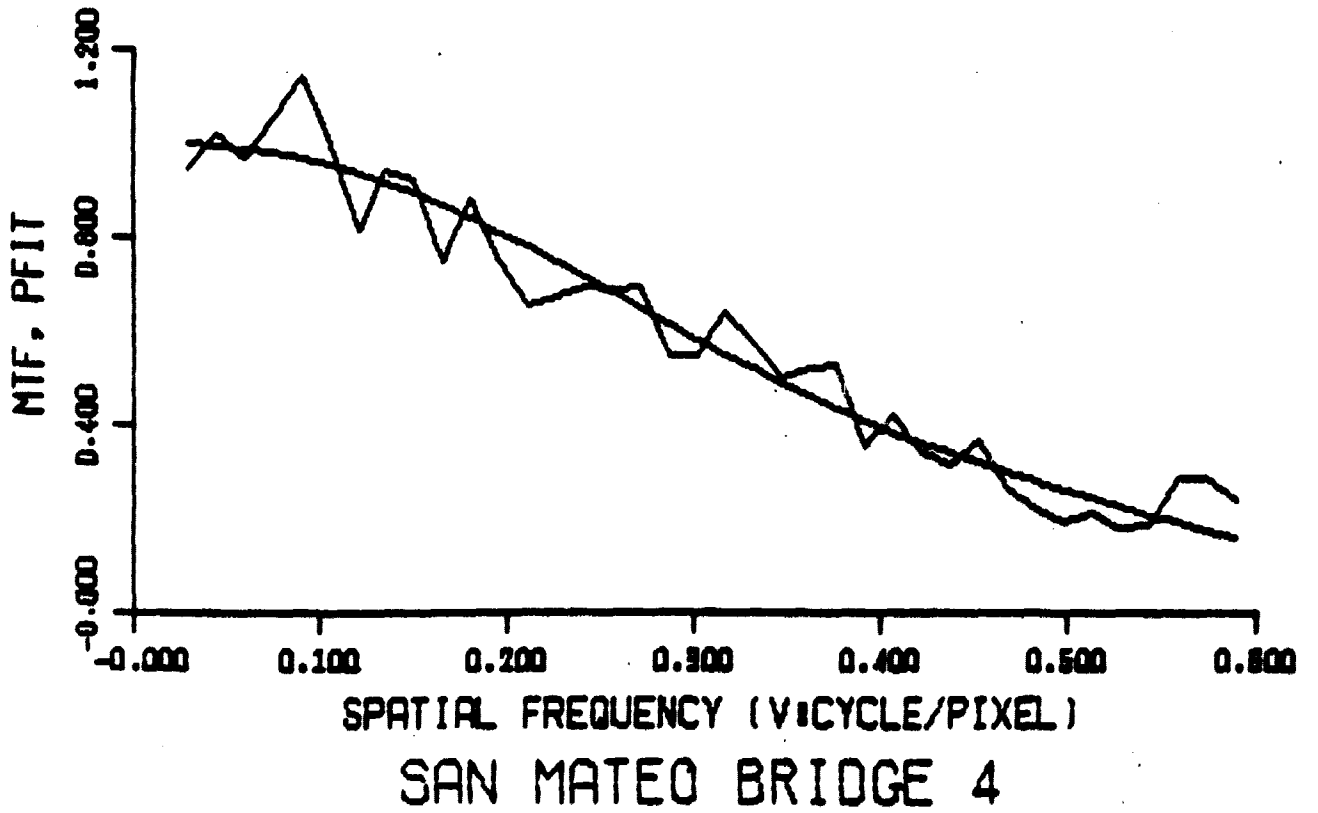




Figure 2. Overall TM system MTFs for bands 3 and 4